THE PRODUCTION OF MALES AND FEMALES CONTROLLED BY FOOD CONDITIONS IN THE ENGLISH HYDATINA SENTA.

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It has been found recently in an American parthenogenetic strain of the rotifer, *Hydatina senta*, from New Jersey that a continuous diet of the colorless protozoan flagellate, *Polytoma*, causes practically all females to be produced.[1] This production of only females can be maintained in this manner through generation after generation for several years. If, however, the diet is suddenly changed to a green protozoan flagellate, *Chlamydomonas*, that is in an active state, males can be produced in great numbers.

It has been suggested that perhaps this phenomenon of the regulation of the two sexes by food conditions is peculiar to this particular strain of New Jersey *Hydatina senta* and is not an universal characteristic of the species. Fortunately it has been possible to test this hypothesis on an English strain of *Hydatina senta* and some very clear and conclusive results have been obtained.

I am greatly indebted to A. F. Shull for the stock of English rotifers with the accompanying data. "The English line was received from Mr. C. F. Rousselet, who collected them as resting eggs in mud at the bottom of a duck pond in England in August, 1912. They were sent to me about November 1, 1912, in dry dirt. The first ones hatched a few days later and from them the line sent to you has been reared by parthenogenesis ever since. As they were reared there was a generation about every three days and so you have about the 270th generation." The stock of this English line was received from Dr. Shull on January 7, 1915.

The females of this strain produce fewer offspring in the same period of time than the females of the New Jersey strain. This

[1] *Jour. Exper. Zool.*, Vol. 17, November, 1914.

is probably due to the fact that the former strain had been reproducing parthenogenetically for several years and had become weakened whereas the latter strain was developed from a resting egg in November, 1914, and at the present time is as vigorous as at first.

The method of making the media and rearing the two kinds of protozoan food cultures has been given in detail in a former paper and will not be repeated here, excepting a few additional words about the green food. When the *Chlamydomonas* had been 2–3 weeks in the same media the individuals were large and more or less quiescent. In this condition they were only moderately effective although in one or two instances some that had been two to three months in the same media were very effective. When they had been in new bouillon media for 2–7 days with considerable sunshine at a temperature of about 28° C. they were of various sizes and seemed to be the most effective. However, there seems to be a considerable amount of chance in getting the *Chlamydomonas* in the optimum condition for every experiment. This probably explains the varying percentages of the male-producing females obtained in the different experiments.

As it seems that the effect of a uniform diet on this rotifer has not been sufficiently emphasized the following Table (I.) con-

TABLE I.

SHOWING THAT A CONSTANT AND UNIFORM DIET OF THE COLORLESS PROTOZOA, *Polytoma*, REPRESSES THE PRODUCTION OF MALE-PRODUCING FEMALES AND CAUSES THE PRODUCTION OF FEMALE-PRODUCING FEMALES.

Kept on a Uniform Polytoma Diet.

Race.	Generation.	♂♀	♀♀	% ♀♀	Time.
A.....	1–288	92	2,565	96+	22 months
B.....	1–181	8	1,731	99+	14 months
C.....	1–288	0	2,749	100	22 months

cerning this point in three pedigreed races has been compiled from the records in an earlier paper.[1] This shows that a constant and uniform diet of *Polytoma* has repressed the production of males for nearly 300 generations. The long period of time

[1] BIOL. BULL., Vol. 22, March, 1912.

and the large number of generations through which these races were reared and observed would seem to warrant the reliability of the results.

Table II. contains the results of some new observations made in November and December of 1914. The main point of interest in it is that it shows at what place or stage after the diet has been changed females may be isolated that will produce a high percentage of male-producing daughters. Adult females (mothers) that were put into the new diet of green food produced in it,

TABLE II.

AS A CONTROL FOR TABLE III. AND ALSO SHOWING THE HIGH PERCENTAGE OF MALE-PRODUCING DAUGHTERS PRODUCED AFTER THEIR MOTHERS HAD BEEN TRANSFERRED FROM THE *Polytoma* DIET TO THE GREEN *Chlamydomonas* DIET FOR 12 HOURS.

Experiments During November and December 1914 on a New Jersey Strain of Hydatina senta.

Experiment.	Control Reared and Continued on a *Polytoma* Diet.				Adult ♀♀s from the Control Reared on a *Polytoma* Diet Transferred to a *Chlamydomonas* Diet.						
	♀♀ Mothers.	Daughters.			♀♀ Mothers.	Daughters Produced During First 12 Hours.			Daughters Produced During Hours 12–24.		
		♀♀	♂♀	♀♂♀		♀♀	♂♀	♀♂♀	♀♀	♂♀	♀♂♀
1	10	10	0	0	6	14	20	59+	0	22	100
2	10	10	0	0	5	33	6	15+	14	12	46+
3	10	10	0	0	5	24	6	20	8	32	80
4	10	10	0	0	5	No record			7	17	70
5	10	10	0	0	10	"	"		31	61	66*
6	10	10	0	0	5	7	13	61+			
7	10	10	0	0	40	No record			9	104	92+
8	10	10	0	0	40	"	"		24	126	84
9	10	10	0	0	40	"	"		30	129	81+
10	10	10	0	0	10	"	"		1	39	97+
	Control continued through 30 additional generations										
	300	300	0	0							
Total....	400	400	0	0	166	78	45	36+	124	542	81+

during 1–12 hours, 15 per cent.–60 per cent. of male-producing daughters, but the same adult females in the second 12 hours produced a much higher proportion of male-producing daughters, usually from 80 per cent.–100 per cent. In most of the experiments the adult females were taken out of the green food after they had been in it 12 hours, in more or less of sunlight, and placed in filtered culture water from a general stock battery jar

in which various protozoa and rotifers were living. They were left in this filtered water for about 12 hours, during the night, without food. During this time each female laid 3–4 eggs and the next morning the old females were taken out, *Polytoma* food was added, and the eggs allowed to hatch. Several hours later the young females that hatched from these eggs were isolated in separate watch glasses and fed *Polytoma* and a species of a small *Euglena*.

In Table III. this same fact is shown again to be true for the English species. However, this is a relatively minor point and

TABLE III.

SHOWING THAT WHEN THE ENGLISH STRAIN WAS SUBJECTED TO A UNIFORM AND CONSTANT DIET OF THE COLORLESS PROTOZOA, *Polytoma*, ONLY FEMALE-PRODUCING FEMALES WERE PRODUCED BUT THAT WHEN IT WAS SUBJECTED TO A SUDDEN CHANGE OF DIET FROM THE *Polytoma* TO A GREEN PROTOZOA, *Chlamydomonas*, AS HIGH AS 85 PER CENT. OF MALE-PRODUCING FEMALES WAS PRODUCED.

Experiments During January and February 1915 on an English Strain of Hydatina senta.

Experiment.	Control Reared and Continued on a *Polytoma* Diet.				Adult ♀♀s from the Control Reared on a *Polytoma* Diet Transferred to a *Chlamydomonas* Diet.						
	♀♀ Mothers.	Daughters.			♀♀ Mothers.	Daughters Produced During First 12 Hours.			Daughters Produced During Hours 12–24.		
		♀♀	♂♀	% ♂♀		♀♀	♂♀	% ♂♀	♀♀	♂♀	% ♂♀
1	10	10	0	0	5	7	4	36+	4	14	77+
2	10	10	0	0	5	8	2	20	5	5	50
3	10	10	0	0	5	4	3	42+	9	3	25
4	10	10	0	0	5	14	4	22+	8	4	33+
5	10	10	0	0	20	29	11	27+	16	27	62+
6	10	10	0	0	20	38	8	17+	7	40	85+
7	10	10	0	0	15	No record			15	13	46+
8	10	10	0	0	20	30	18	37+	No record		
9	10	10	0	0	90	No record			50	76	60+
	Control continued through 20 additional generations										
	200	200	0	0							
Total....	290	290	0	0	185	130	50	27+	114	182	61+

may only be of importance to any one wishing to obtain cytological material.

If Table III. is compared further with Table II. it is evident that they are very similar in all points with the exception that

the percentages of male-producing females in Table III. are somewhat lower than those in Table II. However, both tables show that a continuous and uniform diet of *Polytoma* causes only female-producing daughters to be produced while a sudden change of the food from *Polytoma* to *Chlamydomonas* causes male-producing daughters to be produced in great numbers.

Summary.

1. A uniform diet of the colorless protozoan flagellate, *Polytoma*, continued for 22 months through 288 generations practically suppressed the production of males and caused only females to be produced in the rotifer, *Hydatina senta*.

2. After the adult females had been transferred from the diet of *Polytoma* to the diet of *Chlamydomonas* for 12 hours they produced a higher percentage of male-producing daughters than they did during these 12 hours.

3. The sudden change of food from a constant diet of *Polytoma* to a diet of the green *Chlamydomonas* caused male-producing daughters to be produced in the English *Hydatina senta* about as readily as in the New Jersey *Hydatina senta*.

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